

# Aspects of Threshold Behaviour and Exponential Growth on Laser and Covid-19: Socio-Economic Impact on Our Lives

Preeti Singh Bahadur\*, Pratima Bais\*\*, Shalini Jaiswal\* and Ruchira Srivastava\*

\*Department of Physics, Amity University, Greater Noida(U.P.), India  
Email: (preetisingh2006@gmail.com)

\*Department of Chemistry, Amity University, Greater Noida(U.P.), India  
Email: (sjaiswal@gn.amity.edu)

\*Department of Mechanical Engineering, Amity University, Greater Noida(U.P.), India  
Email: (rsrivastava@gn.amity.edu)

\*\* Department of Economics, Dr. C. V. Raman University, Kota Bilaspur (C.G.)-India  
Email: pratimasingh78@gmail.com

\*\*\*\*\*

## Abstract:

Laser is one of the exceptional inventions of the last century. Laser has become a valuable tool in a variety of fields starting with communication to medical. As we all know Lasers have unlocked fresh fields of science and technology. Laser seems to be very helpful in reducing the difficulty and thus provide a better platform and easier to accomplish our task. Lasers have affected many areas in many ways. As we all know that pandemic situation is here to and affect every individual in a different way. In this article on the basics of Laser we have explained the aspects of threshold behavior and exponential growth on Laser and Covid-19 and also socio-economic impact of covid-19.

**Keywords** —Laser, threshold, covid-19, virus.

\*\*\*\*\*

## I. INTRODUCTION

This COVID – 19, disease which is originated in Wuhan, Huabei Province, China in December 2019. World Health Organization (WHO) has declared the COVID – 19 as pandemic, the global health emergency. It is considered as the most crucial global health calamity. The only way to control and defeat this pandemic was to make people follow social distancing and to restrain them from moving out to avoid social connect. To achieve this objective effectively, the entire country had shut down and all activities had stopped only with minimal human interaction. The Indian government started taking a strong stand against this COVID – 19 in the mid of March. India sealed all internal and external borders by the end of March. From March 22, the whole country is under lockdown phase it

has been extended till May 31, 2020 with some relaxation. The new coronavirus has been responsible for millions of infections globally, causing hundreds of thousands of deaths. The United States of America has seen the highest number of these deaths.

According to a report, the COVID – 19 induced economic disruptions, i.e. up to 135 million jobs could be lost and 120 million people might be pushed back into poverty in India last year, all of this will hit on consumer income, spending and savings.

As we know that year 2020 began with a pandemic of unassailable global scale. The emergence of the unprecedented and unexpected pathogen, COVID-19, has transformed life to a new normal. As the pathogen has started spreading, it has reached every

continent except possibly Antarctica. The coronavirus disease is scattering crossways the country at a speedy step [1]

Corona virus impact all over the world in each and every field, either a small scale industry to manufacturing hub or household workers. The current corona virus impacts the photonics industry in various ways – for example by hindering part of the workforce, troublemaking supply chains and enforcing the cancellation or postponement of trade shows, effectively eliminating one important method for photonics market. Another point is that there are some notable analogies between the virus spread and laser operation. An expert in physics specially in laser physics is well familiar with various aspects of exponential growth.

Well, it will hardly help those to get it explained via laser physics, but I do hope that many peers in photonics will appreciate to get some clearer thoughts on some quite relevant issues, which will sooner or later affect all of us[2]. I have taken up this matter to show the Aspects of threshold behavior and exponential growth on Laser and Covid-19

## II. RESEMBLANCE BETWEEN VIRUS SPREAD AND LASING

Within the context of laser physics [3], a laser gain medium is a medium which can amplify the power of light (typically in the form of a light beam [4]. From lasers, we know that,  $l$  can circulate in a laser resonator, where it experiences gain (amplification) and also some losses. The rate of change can be described with a simple differential equation:

$$\frac{\partial P}{\partial t} = \frac{1}{T_{rt}}(g - l)P$$

where  $P$  is the circulating intracavity power,  $g$  the gain coefficient,  $l$  denotes the losses per round-trip and  $T_{rt}$  is the round-trip time (often a few nanoseconds or even less). The gain depends on the amount of deposited excitation energy (e.g. through optical pumping) in the gain medium. As long as we have  $g < l$ , i.e., the net round-trip gain is negative, the laser is essentially off: although there is constantly some fluorescence light in the gain

medium, it cannot be amplified to any significant level. If the gain exceeds the losses, however, i.e., we get a positive round-trip gain, the intracavity power will rise exponentially (proportional to  $\exp((g - l)t/T_{rt})$ ) until it starts saturating the gain, eventually limiting the further growth. Depending on the laser parameters, there may be some relaxation oscillations until a steady state can be reached (assuming continuous pumping).

## III. BEHAVIOUR OF LASER GAIN AND VIRUS SPREAD

The behavior of virus spread is somewhat similar. Infections are basically always caused by already infected people (apart from the initial infection, e.g. from some animal – usually a rare event). Therefore, the growth rate of the number of infected people is roughly proportional to that number itself. Although various details are substantially more complicated than those in lasers, we have a growth rate growing with the reached infection level, and thus potentially rapid growth over orders of magnitude. Also, we have a kind of threshold behavior similar to that in lasers: if the average number of people infected by one infected person (called the *reproduction factor* or *R factor*) is below 1, the infection will die out; if that number is larger, we will get exponential growth. So the reproduction factor in the epidemic exactly corresponds to the pump parameter of the laser. So a crucial insight is that it makes a huge difference whether the reproduction factor is e.g. 1.1 or 0.9. While 1.1 means growth, potentially until the infection runs out of not-yet-infected people, 0.9 means a steady decline, never reaching a high level.

A very simple model illustrates essential features of a much more complicated system.

In detail, virus spread is really far more complicated to understand than lasers. For example, there is some time delay after infection where the infected person starts spreading viruses for some time. Also, the probability of further infections is not constant, but depends substantially on the region (e.g. the lifestyle of people) and on time (hopefully getting

lower as people acknowledge the problem and learn to react properly). Nevertheless, the aspects of threshold behavior and exponential growth fully apply.

#### **IV. CONCLUSIONS**

By the way, there are of course many other examples for exponential growth and threshold behavior in physics and technology. For example, a nuclear chain reaction essentially behaves like that. Here, exponential growth quickly leads to a nuclear explosion, releasing vast amounts of energy, if exponential growth is not stopped in time. On the other hand, the chain reaction in a nuclear reactor quickly dies out if it is just below criticality – similar to the vanishing epidemic when the reproduction factor gets below unity. Also due to COVID – 19 pandemic the loss of lives causes definite irretrievable damage to the society. It not only affected the society but severely demobilized the global economy. To stop further transmission of the disease in the community, the effected countries have decided to undergo complete lockdown. Due to lockdown all international and domestic flights, railway services (except goods train), truck, bus and vehicles transport are suspended except those who

are associated with essential commodities. In almost all the COVID – 19 effected countries, school and college institutions, coaching institutions, commercial, sports and spiritual institutions are closed. Micro and small industries are suffering a lot. Tourism and transportation sector are also facing utmost difficulties. The level of production has gone very low. The economy of many countries are facing the threat of inflation and increasing rate of unemployment. Lockdown will directly affect the GDP of each country in the world economy. Some of the experts said that human civilization has not faced such an unprecedented emergency after the World War – II. New coronavirus – COVID – 19 has no doubt put forth a remarkably bad effect on the day to day life of entire human society and also on the world economy.

#### **REFERENCES**

- [1] [<https://www.hindustantimes.com/india-news/seven-states-see-rapid-increase-in-covid-19-cases-in-10-days/story-5GGaDEGyQvOhUYRfjI65eN.html>]
- [2] [[https://www.rp-photonics.com/spotlight\\_2020\\_03\\_16.html](https://www.rp-photonics.com/spotlight_2020_03_16.html)].
- [3] Preeti Singh bahadur, International Journal for Modern Trends in Science and Technology, Vol. 04, Issue 12, December 2018, pp.-08-12.
- [4] [[https://www.rp-photonics.com/gain\\_media.html](https://www.rp-photonics.com/gain_media.html)]